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Kongeriget Danmark

**Patent- og Varemærkestyrelsen**
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**PATENT- OG VAREMÆRKESTYRELSEN**

# METHOD AND APPARATUS FOR PORTION CUTTING OF FOOD PRODUCTS OR SIMILAR ITEMS

The present invention relates to a method and an apparatus carrying out said method for portion cutting of products, such as food products, said method comprising the steps of placing the products on conveying means, transporting said products to scanning means and from said scanning means to cutting means on the conveying means, detecting at least one characteristic of each product with said scanning means, sectioning the products using said cutting means, and controlling and regulating at least one cutting process parameter in order to achieve predetermined product portions based on said detected product characteristic.

In Danish utility model no. DK 96 00164 U3 an apparatus for portion cutting of food products is described, which comprises a rotatable cutting unit for sectioning the successive, mutually spaced products, which are guided through the cutting unit by a first and second conveyor respectively. A vision system for detecting the geometry of the products is arranged by the first conveyor. The shape of the products is registered in a control system controlling the machine for portion cutting the products into a predetermined weight, length, or size based on the shape of the products, and controlling the conveying velocity of the first conveyor.

Such an apparatus, a so-called portion cutter, is used in particular in the food processing industry for cutting fish, poultry, pork or beef products of variable shape into predetermined portion types and sizes.

In order to ensure a uniform cutting of the products in predetermined portion types or sizes, it is important that the products do not move on the conveyor, especially in the conveying direction, once the shape of the product is registered by the vision system. This would cause the subsequent cutting to become imprecise. In connection to the apparatus according to DK 96 00164 U3, a holder for retaining the products during cutting is described.

The products are guided on a conveyor and scanned in a vision system. Based on registered product shape and/or average density of the product and the conveyor velocity, the cutting rate of the cutting unit is controlled, so that the portions or slices become uniform or in a predetermined size, so long as no relative movement between the products and the conveyor occurs between the vision system and the cutting unit, and particularly during cutting.

For some food products it is a problem to handle the product on the conveyor, e.g. if it from the shape of the product and/or the product texture follows that the product may easily roll or otherwise move on the conveyor, particularly when rolling or moving during cutting. This result in an imprecise portion cutting and in the case of larger cross section area products the tall end portions have a tendency to tip over. This creates a problem as the rear portion of a product may disturb or hinder the following product in being cut properly. In order to decrease imprecise cutting, it has been suggested to use holding means that act on top of the product which gently presses the product against the conveyor surface as it is being cut, so that the product does not move during the cutting. However, this holding means may cause the product to be slightly disfigured compared to the scanned shape of the product on which the cutting action is based, again resulting in imprecise portion cutting.

Aside from hindering tall end portions in interfering with the cutting of the following product, placing of the products with a spacing from each other for individual scanning of each product is important in order to optimize the portion cutting, e.g. to achieve a set weight of the end portion (the rear or front portion) of a product and/or combine different portion sizes in order to optimize utilization of the product. Presently, a problem encountered with portion cutters is accordingly the fact that the products have to be mutually and precisely spaced from each other during scanning in order to ensure such an individual scanning. This spacing of the products decreases the capacity of the portion cutter and requires individual calculation based on product and conveyor characteristics.

Hitherto, attempts to solve said movement problem has produced other types of holding means, such as supporting or V-shaped conveying means or roller means, or the back end portion being supported by a actively controlled plate, or the control means being programmed to compensate for a predetermined product movement on the conveyor, or the products being brought together after scanning, e.g. as in US 6,407,818 by the use of a slower moving conveyor after scanning which decreases both capacity and speed, or combinations of said holding means.

On this background, it is the object of the present invention to provide a method of the initially mentioned kind and an apparatus for carrying out said method, wherein the products are lying stationary in relation to the conveyor before, during and after scanning and cutting in order to achieve a more precise portioning of products during cutting.

Further, another object of the present invention may be to provide a method of the initially mentioned kind and an apparatus for carrying out said method, wherein the capacity of the apparatus may be increased.

These objects are achieved by a method of the initially mentioned kind and an apparatus carrying out said method, wherein said products are placed consecutively and essentially abutting each other on said conveying means.

Such a method and apparatus allows for (a) a significantly increased capacity of the portion cutter as the conveying means may be filled up with products to be cut and as the output of the portion cutter, i.e. the portion cut product, is continuous, for (b) the products being supported and fixed both perpendicular to the conveying direction, which significantly decreases rolling of the product during cutting, and in particular in the conveying direction, which significantly decreases tipping over of the rear end portion after cutting, back into the cutting means, and accordingly decreases cutting imperfections, basically by being supported and fixed by the ends of each other, and

for (c) further holding means being unnecessary during cutting, and for (d) simplifying the placement of the products to be cut on the conveying means because the operator and/or automated placing means are not required to estimate the precise spacing between to consecutive products, and for (e) simplifying the extraction of the portions at the output end of the conveying means because the portions arrive in a steady flow.

In one embodiment of the present invention said detection step further comprises determining the point of transition between products based on said at least one detected product characteristic. The advantage of this is twofold. Firstly, a determination of transition point enables the portion cutter to cut the product into portions of precisely defined sizes, lengths or weights without placing the products in precisely determined spacing to each other. Secondly, said determination of the point of transition between products may be performed by a conventional portion cutter with scanning means and does not involve further costs such as new or complicated equipment in order to provide more accurate portion cuts.

In another embodiment of the present invention the determining step comprises providing successive product data sets from the at least one detected product characteristic from the scanning means, calculating the summary differences between two successive data set being the sum of the differences between a first data set and a second data set, and determining the location of one point of transition between two products being where one of the calculated summary differences exceeds a predetermined threshold. Said determining step may readily be carried out in many types of existing scanning means, such as the scanning means detecting product contour, colour or structural changes being a conventional camera and/or laser scanner.

In yet another embodiment of the present invention said determining step comprises the summary difference between two data sets, comprising distance data from several sensors in the scanning means, being obtained by

$$\Sigma\Delta = \Delta 1/a + \Delta 2/a + \Delta 3/a +.. + \Delta n/a$$

where $\Sigma\Delta$ is the summary difference, $\Delta 1$ is the difference between a first distance data and a successive second distance data from a first sensor in the scanning means, 'n' is the number of sensors in the scanning means and 'a' is the length between the location of the first set of distance data and the location of the second set of distance data. This embodiment obtains an accurate transition point determination, which is relatively independent of thickness variations along the product.

In a further embodiment of the present invention, at least one end surface of each product is placed essentially perpendicular to the conveying direction. An advantage being the products may better support and fix each other, especially when they are of a regular and uniform shape, and possibly provided with an end surface obtained by said product being pre-cut perpendicular to the longitudinal axis of the product or alternatively being placed such that one end surface is perpendicular to the conveying direction. Further, such a placing of the products eases a calculation of a high summary difference in the transition point between highly irregular products, and thus the determination of the transition point.

In a further embodiment of the present invention, at least one end surface of each product is placed essentially at an angle to the normal of the conveying direction. This eases the calculation of a high summary difference in the transition point between highly regular, closely packed, and uniformly shaped flexible products, and thus the determination of the transition point.

In another embodiment of the present invention each of the products are not mutually aligned with the longitudinal direction of the abutting products. This further eases the calculation of a high summary difference in the transition point between highly regular, closely packed, and uniformly shaped products, and thus the determination of the transition point.

In another embodiment of the present invention each of the products are mutually aligned with the longitudinal direction of the abutting products. This further eases a

calculation of a high summary difference in the transition point between highly irregular products, and thus the determination of the transition point.

In another embodiment of the present invention, the conveying means is a V-shaped conveyor. The support and fixation provided by the products abutting each other is enhanced by the use of a V-shaped conveyor, supporting in the direction perpendicular to the conveying direction.

In another embodiment of the present invention, said scanning means is a ring scanner. The advantage being the provision of a full 360 degrees product contour data set, with full coverage of both floppy and firm product types.

Another embodiment of the present invention further comprises before the detecting step a step of weighing the products. The control means is thus allowed to compensate for density differences or the scanning means and/or control means may in advance be provided with information concerning at least an approximate location of transition points. Also, the weighing is conveniently provided in order to provide information to the control means concerning the density of a product.

Another embodiment of the present invention further comprises a step of inserting a transition marker between products. Said transition marker may provide the only or additional information concerning the transition point to be marked. In this case, determination of transition point is performed by the scanning means in a conventional way. The advantage being added accuracy of determining the transition point.

The method and apparatus according to the invention will now be described, by way of example, with reference to the schematic drawings in which

Fig. 1 is a perspective view of a portion cutter embodying the invention; and

Fig 2A, 2B are schematic perspective views of a product being scanned by scanning means at time $t_1$ and $t_2$, respectively, for determination of transition point.

Fig. 1 shows a portion cutter for carrying out the method according to the present invention, in which the products 100 are placed consecutively and essentially abutting each other on conveying means 1, in this case a first conveyor 1A, transporting the products 100 along the conveying direction indicated with a full arrow and preferably comprising weighing means (not shown) for performing a density estimate of the products 100. The products 100 are transported by the conveying means 1 towards scanning means 2, in the embodiment shown a ring scanner, in which characteristics concerning the products 100 is detected, in this case distance data from several distance sensitive sensors 22 placed in a ring around the conveying means 1, the distance being between product surface and sensor. The products 100 are transported onwards along the scanning means, in the embodiment shown over a relatively small clearance between the first and a second conveyor 1A, 1B in order to enable a 360° contour scanning by the ring scanner. The products 100 are then transported onwards to cutting means 3, in the embodiment shown a rotatable cutter unit, the cutting of which is controlled by controlling and regulating means 4, which is described in more detail below, based on said detected characteristics from the scanning means 2, the transportation velocity of the conveyors and the density of the product. The products are accordingly cut into portions 101 of a predetermined weight, length or size. The cutting has been enabled by providing a clearance between the second 1B, and a third conveyor 1C, respectively.

In Fig. 1 is indicated the method according to the invention comprising products 100 being placed consecutively and essentially abutting each other on the conveying means 1. Consequently, the products 100 are essentially supporting and fixing each other during transport on the conveying means 1, and advantageously during cutting by the cutting means 3. The products 100, preferably food products like fish, poultry, pork or beef meat products, may be pre-cut and/or pre-skinned pieces, or may be entire pieces, and may as such be of different sizes, shapes and densities, and may contain fat, bone, meat and/or ligaments. Also, the products 100 may be of varying

consistency, floppy, delicate, firm, hard, soft, thick, thin, or combinations of these. When the products 100 are being placed essentially abutting each other, they provide support and fixation of each other in a smaller or larger degree depending on meat type, pre-cut shape, and size and shape of the abutting end surfaces of two products placed consecutively and abutting on the conveying means 1.

The placing means (not shown) may simply be another conveyor in communication with said first conveyor, e.g. from a pre-cutting device in the production line, or may be performed by manual feeding or by any other conventional placing device. The way the products are placed on the conveyor influence the accuracy of the transition point determination, and will be described in detail below.

The conveying means may be any type of conventional conveying means, often several conveyors in a series, and often communicating with further conveyors in a production line both from the infeed end serving the first conveyor 1A and from the outfeed end serving the third conveyor 1C, as shown in Fig. 1. The conventional conveyors may for example comprise unidirectional conveyors, linearly directed conveyors and V-shaped conveyors. Especially in combination with a V-shaped conveyor a portion cutter according to the present invention provides an excellent further fixation and support of the products during cutting, especially in a direction perpendicular to the conveying direction. Advantageously weighing means comprises a first conveyor 1A being a weighing conveyor in order to establish data concerning product density for use by said controlling and regulating means 4.

The portion cutter is operated under the control of a controlling and regulating means 4, often a control circuit or processor, and the scanning means 2 supplies the control and regulating means 4 for the cutting means 3 with data, usually with data concerning the contour of the product 100 to be cut, in the embodiment shown being distance data from a ring scanner. In an advantageous embodiment of the invention, the scanning means also supplies data concerning the transition points between

abutting products. The cutting means is in this embodiment a rotatable knife, but may be other conventional cutting means.

In Fig. 1, the ring scanner 2 produces data sets concerning the contour of said product by a detection of the distance from each of the sensors to each their corresponding points on the surface of the product, by correlation of a calibration distance to a reference point. Said data sets may, referring to Fig. 2A, for example comprise a first distance data set $d1_1,d1_2,d1_3,..,d1_n$ acquired from n sensors 22a, 22b,...,22n in one position of the product 100 being scanned at time $t_1$, and referring to Fig. 2B a second distance data set $d2_1,d2_2,d2_3,..,d2_n$ acquired from the same sensors in a second position of the product 100 being scanned at time $t_2$. As may be seen from the Fig. 2A and 2B, the front end surface 102A of each product 100A may advantageously be pre-cut perpendicular to the conveying direction (indicated by arrows) and may be of a larger cross section area than the back end surface 103A of each product is having, enhancing the supporting effect of the abutting products facilitating an accurate determination of the point of transition between two products 100.

In an advantageous embodiment of the present invention, transition points between products may be determined by providing successive product data sets from the at least one detected product characteristic from the scanning means, calculating the summary differences between two successive data set being the sum of the differences between a first data set and a second data set, and determining the location of one point of transition between two products being where one of the calculated summary differences exceeds a predetermined threshold.

The portion cutter advantageously obtains the summary difference between two data sets, comprising distance data from several sensors in the scanning means, by the following formula

$$\Sigma\Delta = \Delta 1/a + \Delta 2/a + \Delta 3/a + .. + \Delta n/a$$

where $\Sigma\Delta$ is the summary difference, $\Delta 1$ is the difference between a first distance data and a successive second distance data from a first sensor in the scanning means, 'n' is the number of sensors in the scanning means, and 'a' is the length between the location of the first set of distance data and the location of the second set of distance data.

$\Sigma\Delta$ (which is not necessarily a measure for differences in the cross section area) is used in the determination of the transition point between two products 100, since $\Sigma\Delta$ along each product 100 is smaller than $\Sigma\Delta$ in the transition point. By having obtained information concerning the product characteristics like product meat type, cut, consistency and the like a threshold for $\Sigma\Delta$ may be established and set in the portion cutter according to the present invention. When $\Sigma\Delta$ exceeds the threshold, the point of transition is determined in relation to that conveyor position, in which the greatest $\Sigma\Delta$ was found inside a predetermined distance from the location in which the $\Sigma\Delta$ exceeded the threshold.

Advantageously, said products 100 may be pre-cut perpendicular to the conveying direction, optionally having end surfaces 102 of essentially of the same shape and size, in order for the abutting products 100 to support and fix each other in an efficient manner during cutting in the cutting unit 3 to be cut into predetermined portions 101 of a selected size, weight and/or length. If each of the two product end surfaces is being cut to approximately same size and shape as the end surfaces of the abutting products, which results in the products 100 being scanned having approximately the same distance data set, the determination of the transition point is facilitated by placing the products 100 either not mutually aligned or with at least one of the end surfaces at an angle with the normal to the conveying direction.

When scanning flexible products, which have either been pre-cut perpendicular to the conveying direction or been placed with the end surface perpendicular to the conveying direction, and the products have relatively uniform end surface cross section area and shape, a placing of such products or at least one end surface of each

such product at an angle with the normal to the conveying direction advantageously facilitates the determination of the point of transition by providing a relatively large ΣΔ at the transition point.

In cases where products are having a cross section of a regular and in terms of size uniform shape, such as e.g. a fixed size circular, triangular, or rectangular cross section, and each product having an end surface obtained by said product being pre-cut perpendicular to the longitudinal axis of the product, it eases determination of the transition point to place said products on the conveying means with an end surface thereof at an angle to the normal of the conveying direction, as this placement approach leads to a calculation of as high a ΣΔ as possible.

In the Figs. 1, 2A, and 2B, the products have been placed consecutively and essentially abutting each other, and have been mutually aligned with the longitudinal direction of the abutting products, i.e. put on a straight line. Alternatively, if the conveyor arrangement allows this, the products may optionally not be mutually aligned with the longitudinal direction of the abutting products. In this way the products may be placed on the conveyor, i.e. either in a serpentine configuration (formed like a snake ( VVV )) and supporting each other by an edge of the end surface, or formed in a stepwise, Z-formed configuration ( \\\\ ). This approach provides for an even higher ΣΔ being calculated.

A transition marker may advantageously be used in order to provide data concerning the transition point to the scanning means, such transition marker being e.g. a foil or a specially formed disc as an insert marker between two products, the marker being kept in place by the abutment of two products. The placing of the marker may e.g. be performed automatically or manually, and at the same time as the products are placed on the conveying means or after.

A portion cutter is a machine cutting larger items into smaller items the latter are called portions. The most popular products to be cut in this way are meat, poultry and fish. The portions are of predetermined size, length, volume or weight.

In the following, the process will be explained according to cutting into predetermined weight size portions, as this is the most complex process.

The items to be cut are placed on a conveyor which in turn takes the items to a measuring device, a cutting device and finally takes the portions out of the machine.

The measuring device is normally a computer vision (scanning) device and a control unit which based on the known conveyor velocity calculates the shape of the items. The shape will be calculated as a curve expressing the accumulated volume (Y axis) by distance (X axis) from the first end of the item. The density (weight to volume ratio) of the product has to be known. If it is not, the item has to weighed prior to the scanning. The shape curve can now be converted into a weight curve and the cutting positions can be calculated by the control unit by finding the corresponding distances from the first end of the item to the weight of the portions.

The cutting device is often a rotating knife (or saw) controlled to cut at the calculated positions. This knife can either be of a type working on top of the conveyor belt of a sword type meaning that the conveyor has to be split into two end-to-end placed conveyors to let the sword pass through the gab between the conveyors. Other cutting devices could be bandsaw, disc saw etc. or a drop knife ultra sound cutting, waterjet cutting or laser cutting, just as well as knives with different shapes may be used dependent of the particular task.

To plan the cutting of the individual items to be cut efficiently it is essential to produce a weight curve for the individual item to be cut. This is best understood by an example: If for instance we want steaks of 125 g or 150 g size and an item to be cut is 800 g this item can be planned to be cut into 2 portions of 150 g and 4 portions

of 125 g (this totals up to exactly 800 g, meaning no waist and therefore best yield and economy).

To obtain this individual curve for each item to be cut it is necessary to make a space at each end of the items when they are fed into the machine.

This space causes two main disadvantages (1) the efficiency of the machine reduces as it takes time to convey the spaces between the items through the machine, and (2) the items can move while they are being cut, especially when cutting close to the rear end of the item as the item easily can tilt when it is short, resulting in imprecise cutting.

Both these disadvantages can be overcome by this invention where the items are positioned abutting each other.

An aspect of the invention is related to being able to find the boundary between consecutive items to be cut when they are placed on the conveyor abutting each other without any gab between them (see figures 3, 4 and 5).

The invention overcomes the first disadvantage as described above as the items to be cut now fill the conveyor completely. Thereby efficiency of the machine cannot be higher.

As to the second disadvantage the benefit is that the items to be cut are unable to move when the subsequent item to be cut is supporting the rear end of it. To avoid the item from tilting in the forward direction it is already known to let the cut portions stay close together without accelerating the conveyor speed until they are in safe distance – this means the cut portions support the uncut piece of the item to be cut avoiding this to tilt in the forward direction.

The value of ΣΔ indicating the boundary between consecutive items is easily found by experience and can be memorised in the machine together with other characteristic values for a specific type of item.

Other characteristic features can be used instead of the heights or in addition to the heights.

Other such features can e.g. be the colour of the items to be cut, the light reflection factors or a combination of these two and others (see fig. 4).

Also, the height can be used in different ways. Above relative change is used (see figs. 3, 5 and 6). This can be with or without sign. True absolute change and relative change to scanline distance have been found to have good performance.

In the above, it is assumed that a flat scanner is used. In some cases, a ring scanner is used. A ring scanner is a scanner measuring the distance from a midpoint of a circle to the item to be cut in a number of lanes or traces arranged in a circle surrounding the item perpendicular to the conveying direction. Measurements from such a device can be used in the same way as described above.

## CLAIMS

1. Method for portion cutting of products, such as food products, said method comprising the steps of

- placing the products on conveying means;
- transporting said products to scanning means and from said scanning means to cutting means on the conveying means;
- detecting at least one characteristic of each product with said scanning means;
- sectioning the products using said cutting means;
- controlling and regulating at least one cutting process parameter in order to achieve predetermined product portions based on said detected product characteristic;

characterised in that

- said products are placed consecutively and essentially abutting each other on said conveying means.

2. Method according to claim 1, wherein said detection step comprises determining the point of transition between products based on said at least one detected product characteristic.

3. Method according to claim 2, wherein the determining step comprises

- providing successive product data sets from the at least one detected product characteristic from the scanning means,
- calculating the summary differences between two successive data set being the sum of the differences between a first data set and a second data set, and
- determining the location of one point of transition between two products being where one of the calculated summary differences exceeds a predetermined threshold.

4. Method according to claim 3, wherein the determining step comprises the summary difference between two data sets, comprising distance data from two or more sensors in the scanning means, being obtained by

$$\Sigma\Delta = \Delta 1/a + \Delta 2/a + \Delta 3/a + \ldots + \Delta n/a$$

where $\Sigma\Delta$ is the summary difference, $\Delta 1$ is the difference between a first distance data and a successive second distance data from sensor 1 in the scanning means, 'n' is the number of sensors in the scanning means and a is the length between the location of the first set of distance data and the location of the second set of distance data.

5. Method according to any of the preceding claims, wherein at least one end surface of each product is placed essentially perpendicular to the conveying direction.

6. Method according to any of the claims 1-5, wherein at least one end surface of each product is placed essentially at an angle to the normal of the conveying direction.

7. Method according to any of the preceding claims, wherein each of the products are not mutually aligned with the longitudinal direction of the abutting products.

8. Method according to any of the claims 1-6, wherein each of the products are mutually aligned with the longitudinal direction of the abutting products.

9. Method according to claim 8, wherein the conveying means is a V-shaped conveyor.

10. Method according to any of the preceding claims, wherein said scanning means is a ring scanner.

11. Method according to any of the preceding claims, wherein said method before the detecting step further comprises a step of weighing the products.

12. Method according to any of the preceding claims, wherein said method further comprises a step of inserting a transition marker between products.

13. An apparatus for portion cutting of products, such as food products, said apparatus comprising

placing means for placing said products on conveying means;

conveying means for transporting said products to scanning means and from said scanning means to cutting means,

scanning means for detecting at least one characteristic of the product,

cutting means for sectioning the products,

control means for controlling and regulating at least one cutting process parameter in order to achieve predetermined product portions based on said detected product characteristics,

<u>characterised in that</u>

said products are placed consecutively and abutting each other on said conveying means.

14. Apparatus according to claim 13, wherein the scanning means determine the point of transition between two products based on said at least one detected product characteristic.

15. Apparatus according to claim 14, wherein

- successive product data sets are provided from the at least one detected product characteristic from the scanning means,
- the summary differences between two successive data set are calculated as being the sum of the differences between a first data set and a second data set, and
- the location of one point of transition between two products is determined being where one of the calculated summary differences exceeds a predetermined threshold.

16. Apparatus according to claim 15, wherein the control means obtains the summary difference between two data sets, comprising distance data from several sensors in the scanning means by

$$\Sigma\Delta = \Delta 1/a + \Delta 2/a + \Delta 3/a + .. + \Delta n/a$$

where $\Sigma\Delta$ is the summary difference, $\Delta 1$ is the difference between a first distance data and a successive second distance data from a first sensor in the scanning means, 'n' is the number of sensors in the scanning means and a is the length between the location of the first set of distance data and the location of the second set of distance data.

17. Apparatus according to any of claims 13-16, where at least one end surface of each product is placed essentially perpendicular to the conveying direction.

18. Apparatus according to any of the claims 13-17, where at least one end surface of each product is placed essentially at an angle to the normal of the conveying direction.

19. Apparatus according to any of the claims 13-18, where the products are not mutually aligned with the longitudinal direction of the abutting products.

20. Apparatus according to any of the claims 13-18, where the products are mutually aligned with the longitudinal direction of the abutting products.

21. Apparatus according to claim 20, where the conveying means is a V-shaped conveyor.

22. Apparatus according to any of the claims 13-21, wherein said scanning means is a ring scanner.

23. Apparatus according to any of the claims 13-20, said apparatus further comprising weighing means for weighing the products before scanning is performed.

24. Apparatus according to any of the claims 13-23, said apparatus further comprising a transition marker between products.

ABSTRACT:

The invention concerns a method and apparatus for increasing the capacity and precision of a portion cutter wherein the items are positioned abutting each other.

An aspect of the invention is related to being able to find the boundary between consecutive items to be cut when they are placed on the conveyor abutting each other without any gab between them.

Fig 1

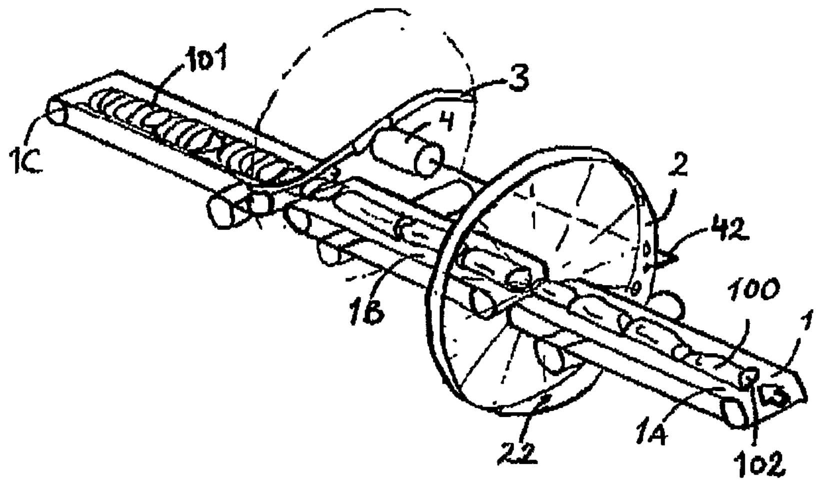
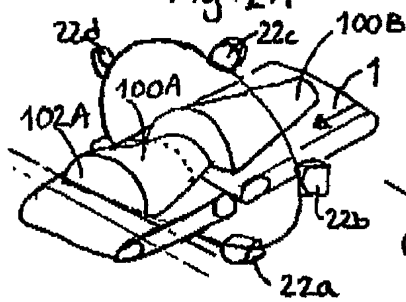
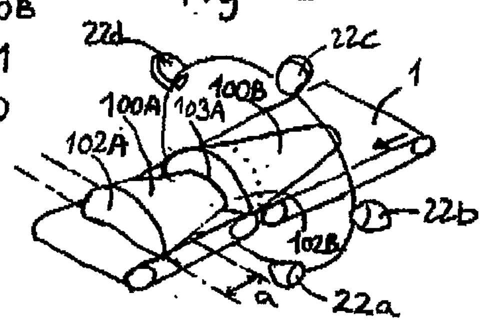



Fig. 2A




$t_1$

Fig. 2B




$t_2$

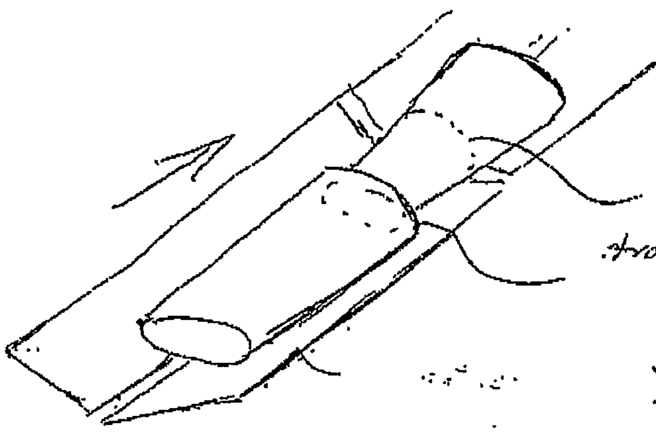



Fig. 3

Fig. 4

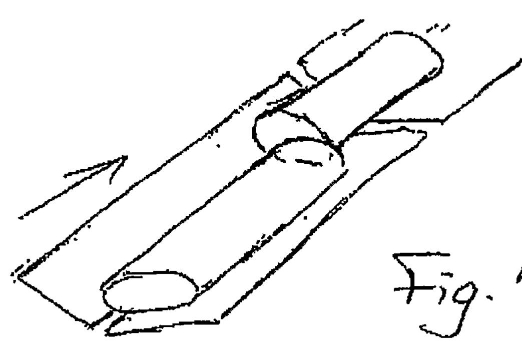
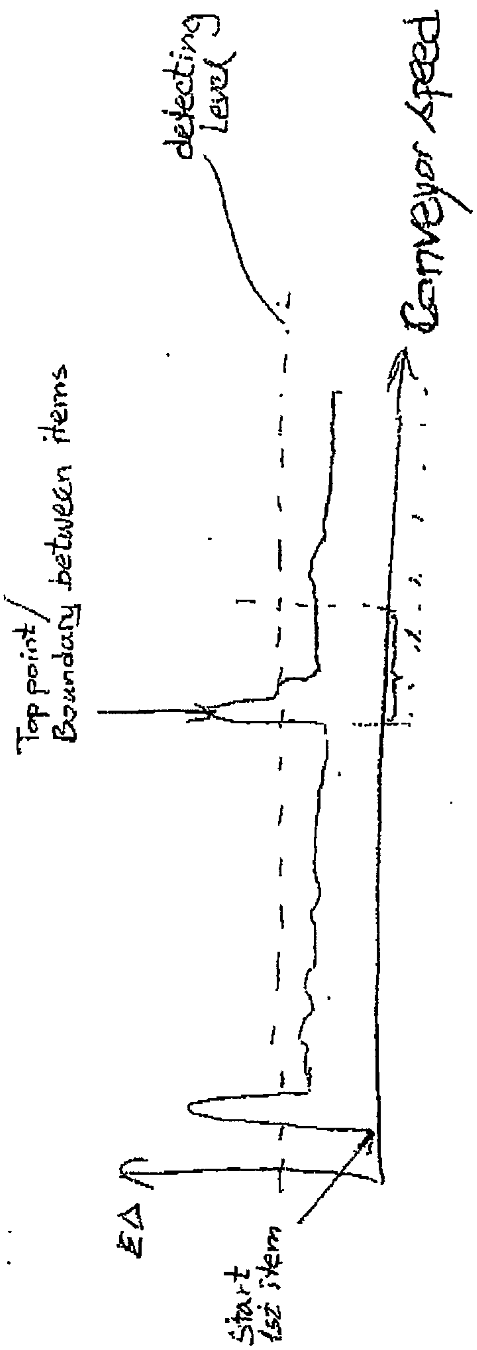


Fig. 5



detecting level
Conveyor speed
Top point/
Boundary between items
EΔ
Start
1st item


Fig. 6